The Need for Technical Warriors

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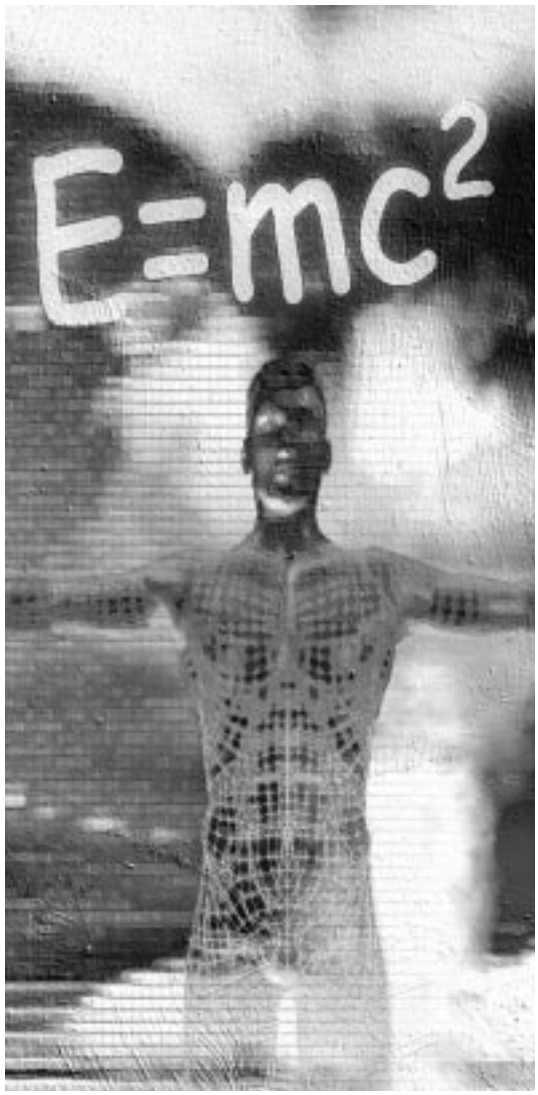
> *A hiatus exists between the inventor who knows what they* [sic] *could invent, if they only knew what was wanted, and the soldiers who know, or ought to know, what they want and would ask for it if they only knew how much science could do for them. You have never really bridged that gap yet.*
>
> —Winston S. Churchill

SINCE THE BEGINNING of World War II, the Air Force has seen the introduction of jet aircraft, radar, atomic bombs, ballistic missiles, computers, lasers, precision-guided weapons, satellites, infrared (IR) (night) sensors, unmanned aerial vehicles, stealth—the list of scientific and technical contributions made to weapon systems is long, and their contribution to the success of the war fighter is nothing short of remarkable.



Science and Technology Advantage to the War Fighter

But as fast as new weapons have been introduced to the operational Air Force, advancements in science and technology have far exceeded even *that* pace, growing at an exponential rate. Records kept for millenia indicate that the world's knowledge, from the dawn of time until the 1950s, has doubled since the 1950s, and the pace is accelerating. This growth of knowledge has spilled over to the war fighter. Today's warrior is now fighting with more technologically sophisticated weapon systems than in the past, and that has resulted in fewer warriors being needed to fight on the battlefield.

Figure 1 shows the dramatic decrease in number density (or warriors per square kilometer) made possible by the exploitation of advanced science and technology (S&T). Introducing S&T in the battlefield has enabled fewer war fighters to levy more damage with more accuracy than in the past. For example,

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2000		**00-00-2000 to 00-00-2000**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The Need for Technical Warriors	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air and Space Power Journal,155 N. Twining Street,Maxwell AFB,AL,36112-6026**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**7**	

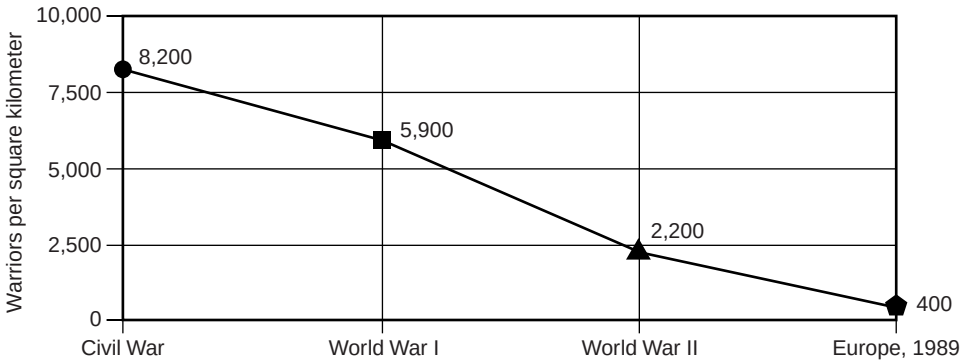


Figure 1. Manpower Density on the Battlefield (per Square Kilometer) (from Kenneth L. Adelman and Norman R. Augustine, *The Defense Revolution: Intelligent Downsizing of America's Military* [San Francisco, Calif.: Institute for Contemporary Studies Press, 1990], 53)

the range of a spear was extended by the bow and arrow; that range and destructive power was extended by a bullet, which was increased in turn by an artillery shell; and that was increased even more by aircraft and ballistic missiles.

In his National War College text on the Strategic Defense Initiative, Col Simon P. Worden expanded on the exploitation of S&T by defining military effectiveness as a basic measure of a weapon's military power.[1] Military effectiveness is a quantitative measure of a weapon's range, accuracy, and lethality (or destructive power) expressed in a single number.

Figure 2 shows the dramatic increase in military effectiveness due to S&T through the years. Here, the *y*-axis is shown as the exponent of powers of 10, so that the maximum value of "25" is not a simple factor of five greater than "20," but 10^5 or *100,000 times greater.*

For example, by Worden's analysis, today's nuclear-tipped intercontinental ballistic missiles (ICBM) are 10^4, or 10,000 times more effective than artillery was in 1930. Although military tactics and strategy have played a role in improving the lethality of these weapons, the stunning increase in military effectiveness is chiefly due to one reason and one reason alone: the advancements made in S&T and their transition to the warrior.

Science and Technology in the Battlefield

The S&T present in the battlefield is increasing. Tomorrow's battlefield will consist of global networks keeping track of targets; sophisticated sensors; information-linked combatants; stealthy air, land, and sea platforms (both manned and unmanned); and long-range, conventional (nonnuclear), high-precision weapon systems, all linked with digital computers.[2]

Figure 2 shows there has been an exponential increase of military effectiveness due to advancements in S&T, and this trend will continue. This means that in the future the Air Force will experience not just increases of a few percent, or even a doubling of military effectiveness, but increases of many thousands of times, all due to the exploitation of S&T.

The implication is that the US military's overwhelming superiority is directly due to research investments in defense S&T made 20 to 30 years ago.[3] This well-substantiated fact is embodied in such products as the F-117 stealth fighter; the B-2 stealth bomber; the Global Positioning System (GPS); cruise missiles; lasers; microelectronics; information tasking, exploitation, processing, and transmission; and small space platforms, to name a few.[4] S&T investment decisions made decades

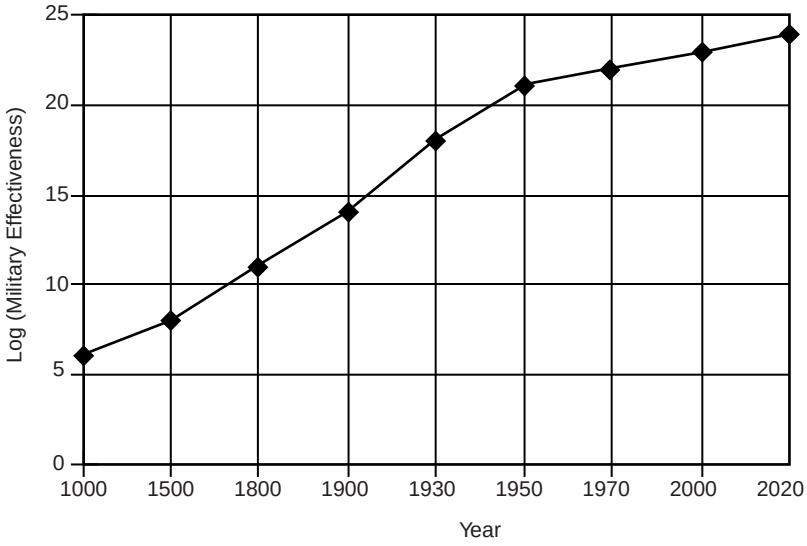


Figure 2. Increase of "Military Effectiveness" (Log Scale) Due to S&T (from Simon P. Worden, *SDI and the Alternatives* [Washington, D.C.: National Defense University Press, 1991], 15)

ago have gotten us to where we are today, so that warriors at the "pointy end of the stick" are sharper, faster, less visible, farther reaching, more accurate, more mobile, and more deadly than ever before—while producing less collateral damage.

Therefore, the lesson is that today's advances in S&T will produce the next generation of weapon systems for the war fighter. But advances in defense S&T do not happen overnight; nor do they happen in a vacuum. In the words of a former researcher at the prestigious Bell Laboratories, "Quality work requires sustained support. You just can't turn on the spigot and have Nobel Prizes overnight."[5] As in any other successful endeavor, S&T requires perspiration and persistence, as well as creativity. In other words, defense S&T needs to be nurtured, looked after, and sustained. Or it will die.

Science and Technology in the Changing Defense-Industrial Base

In the past, an infrastructure consisting of defense laboratories, industry, and academia generated the S&T that would be exploited for producing the next major weapon system. The end of the cold war forced the nation to turn away from maintaining a unique defense-industrial base and rely on the commercial marketplace to accomplish a significant fraction of the S&T needed for tomorrow's weapons.

But the commercial marketplace has also undergone change. Most worrisome, long-range industrial research has dramatically dropped. Corporations now focus on short-term demands, such as manufacturing and time-to-market problems, and have moved away from producing the advancements in S&T that once served as the basis for longer-range projects.[6] While some industries will continue to evolve technologies to develop and retain market share, in general there will be less risk taking and less innovation. And while some enabling technologies of importance to the military will be developed, there will be less integration of technologies for defense purposes.

Without the necessary infrastructure or profit enticements, the commercial marketplace has no motivation to perform research

in some unique areas required by the military services—such as the refinement of bombsights or the cleaning of stealth surfaces, for example. In addition, defense industry has significantly reduced its research and development (R&D) investments as military procurements have been drastically reduced, which greatly decreases industry internal R&D (IR&D). Aside from the opportunities to establish joint interests in such dual-use areas as space technologies, industry is moving away from long-term research.

Although defense laboratories are in a position to take up the slack, they are also suffering significantly as they too downsize and have difficulty attracting top talent. This problem is not unique to the Department of Defense (DOD); the Department of Energy's national security laboratories have the same problem.[7] Despite this, the DOD laboratories have a vital function in providing the critical transition bridge of S&T so that the right weapon with the right enhancements gets to the war fighter.

The Need for Technically Competent Warriors

The sophisticated nature of S&T demands the attention of experts. Just as it takes many years of experience to become an Air Force pilot, to exploit the appropriate S&T for the war fighter demands years of schooling and research experience.

Certainly a cadre of technical civilians is needed to support the defense S&T base. They would provide long-term continuity and allow the eagerness for the future to be tempered by reality and the lessons of the past. Some even argue that because the mission of the military is to fight and win wars, this cadre of scientific personnel should consist *only* of civilians—leaving the war fighting to the warriors and allowing this civilian cadre to produce new weapons. There is a good point to the argument that the military should focus on its core competency of fighting.

But war fighters cannot be insulated from the process of getting the right weapon to the field. Warriors have to be involved in this process, and they must have the right background from which to do it. These warriors must be technical officers who are competent in S&T and are able to understand and influence *all* phases of the acquisition process—from the scientist performing basic research, to the industry executive building the weapon system—to get the war fighters what they need. Unlike civilians (including retired military), technical warriors provide an *immediate, operational context* to focus S&T for maximum utility.

Technical officers have been exposed to a much greater breadth of military experience than their civilian counterparts. This makes the officer an "insider" to the war fighter's confidence and needs—a true "technical warrior." This is especially important when transitioning S&T, since defense S&T is inextricably tied to its final products—the weapons of war. Furthermore, sophisticated weapon systems demand that no discontinuities exist across the research and implementation phases from their birth to their use. Otherwise, this "interface" problem of transitioning S&T may cause something that is well intentioned but operationally lacking to be delivered to the field.

Therefore, the best way to ensure that a credible transition exists is to have a warrior be accountable for the weapon from birth to death. This demands a small but dedicated cadre of technically smart warriors—those who are closest to the war fighter yet have an impeccable grasp of technical subtleties, coupled with savvy and strong common sense—to maintain the continuity. But they cannot do it alone. These technical warriors must interact closely with long-term civilian S&T experts, as well as industry, academia, and other national assets.

Reasons for Having Technically Competent Warriors

The following reasons for nurturing a cadre of technically competent warriors have been culled from a wide variety of sources—

from bench-level scientists to vice presidents in major corporations, and from war fighters to senior executives throughout the government. Because of the dynamic job responsibilities of Air Force decision makers, it is important that these reasons be highlighted so that leaders can be made familiar with the underlying arguments.

1. The Air Force needs technical warriors to be smart buyers. By wearing the uniform, technical blue suiters are treated differently from their civilian counterparts. The operational experience of officers (or even the *perception* of this experience) gives them a stamp of authenticity among industry, academia, and other government agencies. An officer knows firsthand what the war fighter needs. And that knowledge just cannot be conveyed as convincingly through a civilian because it is *the presence of the uniform and the proximity to operational experience* that make the difference.

But wearing the uniform is not enough. The technical officer must have the appropriate academic credentials and research experience to be trusted by the S&T community. Just as the wings of a trained pilot give a stamp of credibility to rated officers, a doctorate degree is the "union card" that can open doors outside the Air Force.[8] It has been proven that technical blue suiters can be accepted and can move between both worlds, serving as smart buyers to get the war fighters what they need and when they need it. Plus, officers with a doctorate degree solve problems differently than war fighters do. They provide the ability to conceptualize, generalize, and synthesize, giving the war fighter access to a greater breadth of information.

2. The Air Force needs technical warriors to have a strategic view. The war fighter must react to short-term threats that may require quick technical solutions. Technical warriors with operational knowledge can help, either because of direct knowledge or by having access to the appropriate technology. In addition, there are longer-range problems that require more time and thought than simply reacting on a crash basis. The end of the cold war has severely constrained the budget for "getting anything at any cost, and getting it done yesterday." These problems require long-term strategies that lie beyond the quick reaction time needed of the war fighter. These are classes of persuasive threats and emerging challenges. Two examples are national missile defense and space control.

Responding to these highly technical, strategic problems requires a cadre of warriors with the scientific backgrounds that simply cannot be obtained through short-term training courses. These officers can couple the war fighter's short-term needs with long-term strategies to meet future threats and needs. In addition to having an operational viewpoint, these technical warriors can understand the realities, capabilities, and limitations of what S&T has to offer.

3. The Air Force needs technical warriors to serve as honest brokers. War fighters need to have access to the skills of a technical facilitator and translator who can easily move between two worlds—that of the warrior and the S&T community—and who can rise above parochial interests.

Simply witness the number of companies vying for defense contracts. It is hard for the war fighter to make a sound technical decision after hearing conflicting presentations that sound equally promising or baffling. However, having one of their own as an honest broker allows the war fighters to do what they have been trained to do: win the war.

4. The Air Force needs technical warriors to keep the S&T community honest. The S&T community knows the technical warrior is a peer and not an outsider, one who can be neither baffled nor patronized. Thus, the technical warrior can call a bluff and "run up the BS flag" if the S&T community is not forthright.

Conversely, technical warriors can serve as advocates for the S&T community if there is a technical breakthrough that deserves immediate, high-priority attention—witness the astonishingly short development time for the "bunker buster" penetrator during the Gulf War. Presenting better weapons to war fight-

ers with the facilitation of technical warriors will help win wars.

5. War fighters need technical warriors to be extensions of themselves. Technically competent warriors are needed to integrate across the seams of weapon-development stages, from cradle to killer. They must be equally at home, from the scientific bench to the office of the industry executive who is producing the new weapon system. Fundamental to this requirement is acceptance as a technically savvy, knowledgeable peer.

By having a warrior in this role, the war fighter works with a trusted blue suiter, one who has access to the fast-paced and dangerous climate of a war zone, as well as the esoteric research lab. The bottom line is that technical warriors have the war fighter's best interest in mind because they themselves are warriors.

Growing Technical Warriors

Just as the Air Force would not hesitate to put a rated officer in charge of a flying wing, put a military doctor in charge of medical care, or make a judge advocate general responsible for resolving legal issues, ensuring that the best S&T is exploited for national security demands no less than a military, scientific professional overseeing S&T concerns. In this era of exponential growth of scientific knowledge, *not* having a cadre of scientifically competent officers responsible for defense S&T is akin to conducting a battle with no war fighters. The idea is simply unthinkable.

Technical warriors can transition discoveries in basic research, through a creative concept of operation, to a weapon that satisfies a war-fighting requirement. Carrying the fledgling weapon across the "seams" through the sophisticated stages of the development process ensures continuity. Technically competent warriors are needed to recognize the future utility (or futility, as illustrated by the Navy's A-12 debacle) of a discovery and to transition the concept to become a militarily useful weapon.

Most importantly, technical warriors can keep the weapon focused on its ultimate use of supporting the war fighter. They can ensure that it doesn't become burdened with additional requirements, which are usually placed on weapons by a well-meaning bureaucracy. And they can do this by following the weapon through its life cycle from the scientific bench to the hands of the war fighter, providing a seamless transition.

But as noted before, obtaining a cadre of high-quality technical officers doesn't happen overnight. As with any group of motivated people, technical warriors must be shown career incentives if the highest caliber individuals are to be retained. Otherwise, the best and brightest will seek upward mobility elsewhere.

To that end, the Air Force Scientific Advisory Board (SAB) recently recommended to the secretary of the Air Force and the chief of staff that "we must have a path for more scientific and technical officers to attain the highest positions in our Air Force."[9] Thus, "the Air Force should consider career management of technically oriented officers with the same vigor as that of the rated force."[10]

In blunt language, this means providing technical officers with a clear and unambiguous path for promotion. Science and technology assignments must be viewed as career enhancing, and leadership opportunities must exist at all levels. For example, the Air Force Research Laboratory (AFRL) provides an excellent opportunity to grow superior technical warriors. By making slight modifications to its already successful structure, the AFRL could be a model for defense S&T.

To illustrate the point, most major Air Force units have adopted the traditional wing structure. Test wings exist, and even the US Air Force Academy's Office of the Commandant of Cadets has become a wing. By using waivers and by acknowledging the AFRL's similarity to a numbered Air Force by both the presence of a flag command and by size, it would be easy to establish "research wings" located at the major research sites already in existence. This would provide real wing-level opportunities for a spectrum of technical of-

ficers, from squadron and wing command, to S&T finance and S&T logistics. In addition to bringing the S&T structure in line with the operational Air Force, it would provide ample leadership opportunity for growing technical warriors.

Conclusions

S&T is fundamental to the war fighter. The best way to exploit S&T is to have technical warriors—competent military officers who have credibility both with the *war fighters* and the *S&T community*. The only way to ensure the highest quality technical warriors is for the Air Force to make a commitment to educate and promote a small cadre of officers to fulfill this role.

If the Air Force wants to maintain its S&T edge, it must have officers who can "speak the language," who can competently serve as an interface between both the warrior and industry, and who have both *technical vision* and *experience*. These officers need to be *grown* and need to have *a technical mind-set*—not just officers who have been exposed to S&T; for you will then simply get officers with advanced degrees and a casual acquaintance with S&T—not true technical warriors. For example, the Navy has made a commitment to produce and promote its technical officers through a rigorous, well-defined program for "EDs" (engineering duty officers), who are tasked with a wide spectrum of technical duties, from ship to flag position.

Finally, *a clear, upward path must be available* for technical officers. A pool of technical warriors is needed in the officer corps, with the means to choose or identify the best and to place them in senior leadership positions. Research wings under the Air Force Research Laboratory umbrella would provide an ideal structure. In these days of highly visible, national-priority, high-tech programs—space-based lasers, national missile defense, airborne lasers, and directed-energy weapons, to name a few—technical warriors are needed for the Air Force's future, now more than ever.

Finally, to paraphrase a recent Air Force SAB study, in today's rapidly changing, uncertain world, the technical warrior must provide the Air Force with capabilities to conduct any mission, meet any contingency, dominate any battlefield, and win any war. Only then will the ultimate goal of defense S&T be accomplished—winning the war. □

Notes

1. Simon P. Worden, *SDI and the Alternatives* (Washington, D.C.: National Defense University Press, 1991), 13–15.
2. Kenneth L. Adelman and Norman R. Augustine, *The Defense Revolution: Strategy for the Brave New World* (San Francisco: Institute for Contemporary Studies Press, 1990), 53.
3. Genevieve J. Knezo, *Defense Basic Research Priorities: Funding and Policy Issues* (Washington, D.C.: Congressional Research Institute, 90-506 SPR, 24 October 1990), 12.
4. Institute for Defense Analysis, "Report of the Task Force for Improved Coordination of Science and Technology Programs," Washington, D.C., August 1988, 8.
5. Dr. Cammy Abernathy, professsor of material science at the University of Florida, quoted by Robert F. Service in "Relaunching Bell Labs," *Science* 272 (3 May 1996): 639.
6. "Basic Research White Paper," *R&D Magazine*, October 1997, 9; on-line, Internet, May 1998, available from http://www.rdmag.com.
7. J. Douglas Beason, *DOD Science and Technology Strategy for the Post-Cold War* (Washington, D.C.: National Defense University Press, 1997), 76–77.
8. The quintessential story of what can go wrong is of the dynamic captain sent to brief industry. After a presentation that impressed industry officials, the captain was asked to view some equipment in the laboratory. The officials were dismayed when the captain did not even recognize the very equipment that he had just briefed. It was then discovered that the captain had memorized a "canned briefing" and had not understood a single concept outside of his presentation.
9. *New World Vistas: Air and Space Power for the 21st Century*, summary volume (Washington, D.C.: USAF Scientific Advisory Board, 1995), 62.
10. Ibid., 69.